343877

NHTSA 7/91

NHTSA-05-22223-20

EFFECT OF CAR SIZE ON FATALITY AND INJURY RISK

Overview

In recent years, as cars have been reduced in size and weight relative to vehicles produced before the early 1970's, there has been a heightened interest in determining the effects of these changes on motor vehicle safety. To address these questions, the National Highway Traffic Safety Administration studied the effect of changes in car size on fatalities and injuries to car occupants in rollover crashes, two-car crashes, and collisions of cars with trucks and fixed objects. After a general overview of the effects of car size, each of the individual studies is reviewed and discussed. While the agency has completed key analyses as of April 1991, it will continue to study the problem as additional data become available.

Effect of Car Size

During model years 1970-82, passenger cars became substantially smaller in the United States. The median curb weight of new cars involved in fatal crashes decreased by about 1000 pounds (from 3700 to 2700 pounds), the wheelbase by about 10 inches, and the track width by 2 or 3 inches. The size reductions of the 1970-82 period were the result of a market shift from full-sized cars to subcompact and imported cars and, after [illegible], downsizing within many domestic car lines. Since 1982, the average size of <u>new</u> cars has remained rather stable. The average size of the entire automobile fleet, however, continued to decrease throughout the 1980's as pre-1975 cars were gradually retired and replaced with new cars - and it is only now approaching 2700 pounds.

Based on studies completed as of April 1991, NHTSA estimates that a reduction of the average weight of new cars from 3700 to 2700 pounds (or the associated reductions in car length and width) resulted in increases of nearly 2,000 fatalities and 20,000 serious injuries per year.

Car size has a much larger effect on fatality risk in rollover crashes than in other crash modes - not because small cars are less crashworthy in rollovers, but because they are more rollover prone. Narrower, lighter, shorter cars tip over more easily than wide, heavy, long ones under the same crash conditions. The analysis methods do not identify which individual vehicle size parameter (track width, curb weight, wheelbase, etc.) is the principal "cause" of this added rollover proneness. Nevertheless, the analyses show that about two-thirds of the increase in fatalities occurs in rollover crashes.

Analyses also show that small cars are less crashworthy than large cars. For example, small cars may offer inferior protection against intrusion by fixed objects into the passenger compartment. The larger expanse of structure in full-sized cars may help cushion the occupant against deceleration forces. The 1000 pound weight reduction is associated with increases of about 10 percent in fatalities and serious injuries in single-vehicle nonrollover crashes.

In a collision between two cars, it is well known that the occupants of the lighter car fare much worse than the people in the larger car. The smaller the car, the greater the vulnerability to injury, but this added risk is at least partially compensated by the fact that small cars are less able to inflict injuries on the occupants of other vehicles. For this reason, a few safety experts have argued that fleetwide reductions in car size would not increase serious injuries in two-car collisions. NHTSA's analysis, however, reveals that a collision between two small cars is more likely to result in serious injuries than a similar collision between two large cars, by almost 10 percent for a 1000 pound weight reduction.

The findings from the accident data - that small cars are inherently less safe than large cars - are supported by an analysis of crash test data from the agency's New Car Assessment Program (NCAP). In that program, the agency provides information to consumers on the relative frontal protection offered to occupants in a 35 mph barrier crash. The test can be likened to two similar vehicles striking each other head-on, each traveling 35 mph (70 mph closing speed) or the vehicle striking an immovable object, such as a bridge abutment, at 35 mph.

From an analysis of 250 crash tests, the agency concludes that small, light vehicles expose the occupants to more danger than large, heavy cars. This occurs because crash forces are imposed on the small car occupants quickly and in a concentrated manner, while occupants of large cars experience a more gradual deceleration. The forces result in the occupants of small cars contacting interior components at higher velocities than do those in larger vehicles, with a greater potential for injury or death.

Relationship of Safety to Fuel Economy Rulemaking

While some hint that this is a "new" issue, raised solely to combat higher CAFE standards, the facts show that the Department of Transportation has long been concerned over the potential tradeoffs between fuel efficiency and safety and has voiced those concerns numerous times over the past 14 years. For example, in March 1977, as part of a Notice of Proposed Rulemaking to reinstate the automatic occupant protection standard, NHTSA stated that fuel economy standards were "expected to result in the reduction of the size and weight of many passenger cars [and] the lighter vehicle is less safe for its occupant, because less vehicle mass and crush distance are available to absorb crash forces. Improved vehicle structures are expected to compensate for reduction in weight and size to some degree, but it appears that <u>the safety need for occupant protection may increase in the relatively near future</u> (emphasis added)." In the final rule on this subject published in July 1977, the agency again stated that "the trend toward smaller cars to improve fuel economy...contains potential for increased hazard to the vehicle's occupants." And, in the first ever fuel economy rule issued by the Department (June 30, 1977), the safety issue was again raised, with the statement that "reasonable conclusions can be made...that there will be a significant adverse safety impact [of fuel economy standards]" unless other measures are taken to counteract these effects.

In more recent fuel economy rulemakings (for example, the agency's October 1986 decision to amend the model years 1987 and 1988 passenger car fuel economy standards), the agency expressed concern that, while standards in the range of 26.0-27.5 mpg would not have adverse safety effects (because of the small range and the lack of leadtime for manufacturers to redesign their products), standards above 27.5 mpg could have a significant impact on safety if consumers were "forced" into smaller and lighter cars. In these rulemakings, the agency repeatedly stated that, if it were to consider setting standards above 27.5 mpg in the future, and if such standards would result in further weight reduction, adverse safety effects would occur. Major downsizing of vehicles would result in a tradeoff of lives and injuries for improved fuel economy.

Other Studies on the Relationship of Car Size to Safety

The Department is not alone in being concerned over the size and weight of vehicles and resultant effect on safety. During the past 12 years, numerous public and private groups have studied the relationship of car size to safety. The Office of Technology Assessment of the United States Congress, the National Safety Council, the Brookings Institution, the Insurance Institute for Highway Safety and the General Motors Research Laboratories all agreed that reductions in car size and weight pose a safety threat.

Effects of Regulations and Improved Traffic Safety

The agency and other safety specialists attempt to improve vehicle safety through a variety of programs. Occupants of vehicles of all sizes are benefiting from improvements in roadway and vehicle design, increased safety belt use, reduced alcohol involvement, state and local programs to improve highway safety, and other factors. These efforts to improve safety will continue. As a result of these efforts, fatalities per vehicle mile traveled, fatalities per registered vehicle, and fatalities per population continue to decline over time. The decrease in car weight (despite the association between car weight and safety in any one year) has not led to increases in the absolute annual number of fatalities, though it has led to fatality savings foregone by the shift to lighter cars. It is the continuing overall improvement in safety that has led many safety specialists to doubt that there actually is an association between car weight and safety.

One of the principal safety improvements has been the increase in safety belt use. NHTSA has found that safety belts are especially effective in preventing occupant ejection in rollover crashes, where the majority of fatalities among unrestrained occupants involve ejection from the vehicle. Since reductions of car size increase fatalities in rollovers more than in all other crash modes combined, one of the best ways to combat the safety problem of smaller cars is to achieve continued increases of belt use.

National Academy of Sciences Study

To further address the issue of fuel economy and safety, in December 1990 the Department of Transportation announced that it would sponsor a study by the National Academy of Sciences (NAS) to determine the potential for improving fuel economy for new passenger cars and light trucks in the next decade, while still meeting environmental and safety needs. As Secretary of Transportation Samuel K. Skinner noted in announcing this study, "Our goal is to provide the American people with cars and light trucks that offer the best feasible combination of safety, fuel efficiency, and cleaner air."

The first phase of the study is scheduled to be completed in Summer 1991. It will result in estimates of fuel economy levels that are practical and achievable over the next decade, and will identify those technologies that could bring them about. It is also expected to identify any barriers to the rapid marketplace introduction of the suggested fuel-saving technologies. A second phase of the study, scheduled for completion by March 31, 1992, will expand upon the earlier findings, and consider other appropriate aspects of fuel economy.

Safety consequences are a key part of this study. Among the factors included in the study are the state of the art in the applications of technologies relevant to achieving higher fuel economy and improving safety, the likely effects of these technologies on vehicle safety, and a consideration of the impacts of heightened public concerns for safety. This study should shed additional light on potential trade-offs between fuel economy and safety in the future.

Summaries of the Analyses

There are five principal types of crashes involving passenger cars; during 1987-89, annual counts of passenger car occupant fatalities in these crash modes, based on the Fatal Accident Reporting System (a census of fatal crashes), were approximately as follows:

o Rollover	4,500
o Single-vehicle nonrollover (e.g., impact with tree)	7,000
o Collision of two passenger cars	5,000
o Collision of car with light truck, van or utility veh.	4,500
o Collision of car with large truck	2,500

Each crash mode is analyzed separately because the influence of car size is different (crash-proneness, crashworthiness). Also, because of data limitations, the effect of car size on fatalities may be derived from a different data source or analysis method than its effect on serious injuries. That results in a matrix of individual analyses.

The Fatal Accident Reporting System contains records of hundreds of thousands of fatalities, but is used only for the analysis of rollovers: in nonrollovers the objective is to study fatality risk per 100 crash involved persons (crashworthiness) and that cannot be done with FARS, which is limited to fatal involvements. For nonrollovers, State accident files are more useful because they offer documentation of all passenger cars involved in reported crashes, whether the driver is injured or not. Individual large State files are excellent for studying the effect of car size on the risk of serious injuries, but the fatality sample from any one State is much more limited. Based on State data analyzed so far, statistically meaningful results have been obtained on fatalities in single-vehicle nonrollovers, but not yet on two-car crashes and collisions of cars with large trucks.

The analysis of collisions of cars with light trucks has been hampered by a lack of detailed information on the weights of light trucks. NHTSA will study that crash mode when such data become available.

The analyses of rollovers and injuries in single-vehicle nonrollovers have been previously published. The other statistical analyses are new material. Another analysis utilizes agency crash test data to evaluate the effect of weight on the risk of injury,.

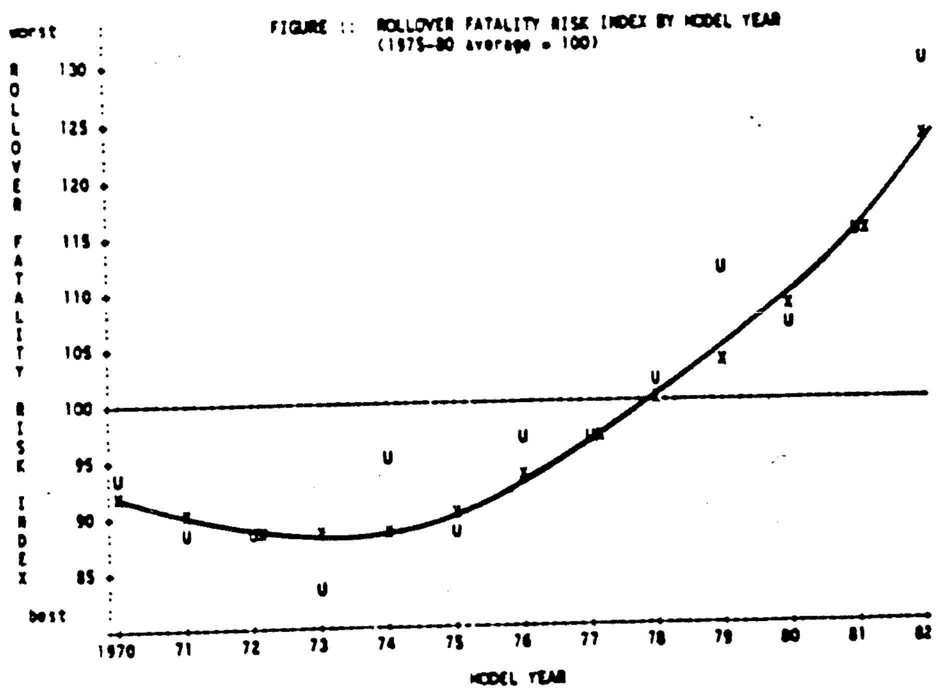
All of the analyses study the effect of historical changes in car size on injuries and fatalities. They describe what actually happened to cars in the 1970's and 1980's, as they changed in size and weight. The quantitative relationships between car size and injury or fatality risk that have applied in the past 20 years cannot necessarily be projected into the future, especially if the next generation of cars is substantially smaller than the mix on the roads today. Nevertheless, the agency believes the analyses are instructive in not only showing the safety effects of past downsizing but are also the direction of the safety effects which can be expected with future changes in vehicle size and weight.

Analysis of Fatalities in Rollovers

Rollover crashes typically involve a car running off the road into uneven terrain, where it encounters tripping mechanisms such as loose soil or a ditch. In general, wide, long, heavy cars have low rollover rates: they are less likely to spin out of control and leave the road than narrow, short, light cars and even when they leave the road, they are less likely to be tripped. Crashes in which a rollover is the most harmful event or principal source of damage account for about 4500 fatalities per year to passenger car occupants.

The estimate of the effect of car size was studied by analysis of trends in rollover fatality risk in cars of model years 1970-82, when passenger cars became substantially smaller in the United States. The measure of fatality risk is the ratio of fatalities in rollovers to fatalities in frontal impacts with fixed objects. The number of frontal impacts with fixed objects, intuitively, is proportional to the frequency at which aggressive or inattentive driving results in cars heading off the roadway - potential rollover scenarios. The less rollover-prone the car, the fewer potential rollover scenarios become actual rollovers - and the lower the ratio of rollovers to frontal impacts with fixed objects. The data source is the Fatal Accident Reporting System (FARS) for calendar years 1975-86.

Figure 1 shows the rollover fatality risk index by model year (1970-82), comprising the net effects of all changes in rollover propensity or crashworthiness of passenger cars. The data points are the ratios of fatal rollovers to fatal frontal impacts with fixed objects, indexed so that the average ratio for 1975-80 comes out to 100. A smooth curve through the data points starts at about 90 in the early 1970's and rises steadily after 1975 to about 123 in model year 1982.

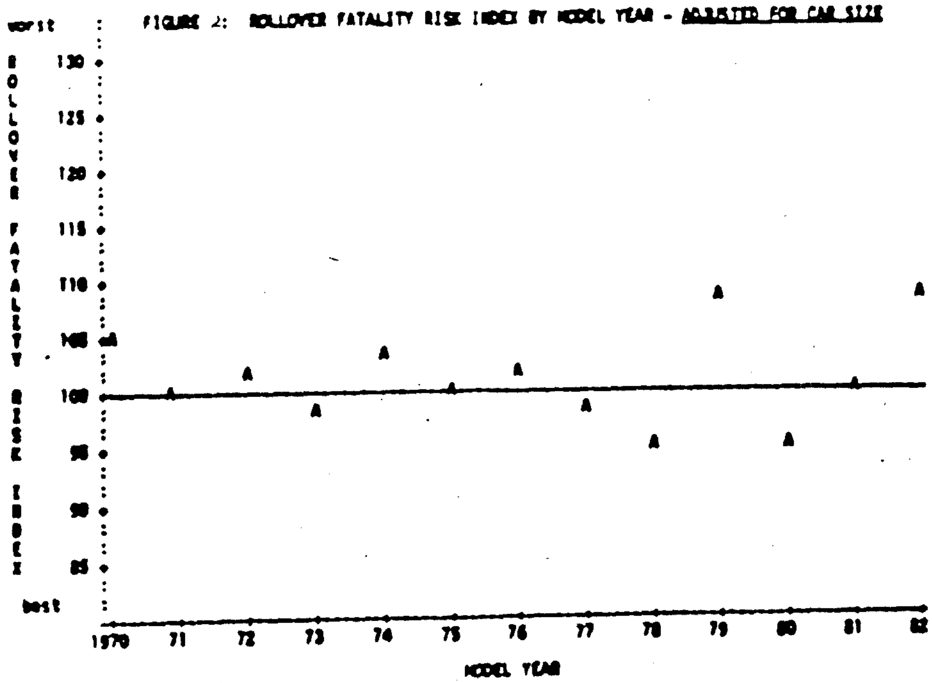


A principal task of the analysis was to determine the extent to which the trend in Figure 1 is due to the increased rollover propensity of smaller cars as opposed to other factors such as crashworthiness. The task was accomplished by splitting up the cars of each model year into car size groups and performing a regression of rollover risk as a function of car size parameters: track width, wheelbase and curb weight. The parameters are highly intercorrelated, in that "large" cars tend to be wide, long and heavy, while "small" cars, with few exceptions, are narrow, short and light.

Figure 2 shows the residual variation in rollover fatality risk in model years 1970-82 after the effects of the car size parameters are removed. This index of fatality risk index by model year - adjusted for car size - is close to 100 and remains essentially unchanged throughout 1970-82. Thus, the increase in rollover fatality risk during 1970-82 (Figure 1) was not due to a change in crashworthiness but occurred primarily because cars got smaller and tipped over more easily.

During calendar years 1987-88, there were an average of 4,500 rollover fatalities per year and the mix of passenger cars on the road had size and weight similar to the model year 1982 fleet, which has a fatality risk index of 123 (Figure 1). If the current fleet had the size characteristics of 1970-75 cars, the index would be reduced to 90 and there would be only 4500 (90/123) = 3300 rollover fatalities. The increase of 1200 fatalities between model years 1975 and 1982 occurred despite a major shift from 2-door cars to 4-door cars which occurred during the same period and is estimated to save 140 ejection fatalities per year. Thus, the net fatality increase due to car size reductions is 1200 + 140 = 1340 fatalities per year.

FIGURE 2: ROLLOVER FATALITY RISK INDEX BY MODEL YEAR - ADJUSTED FOR CAR SIZE



Analysis of Serious Injuries in Single-Vehicle Nonrollovers

Single-vehicle nonrollover crashes often involve a car running off the road and striking a fixed object such as a tree, utility pole, guard rail, or bridge. In other cases, a car might have multiple small impacts in rough off-road terrain. Single-vehicle nonrollover crashes account for about 50,000 injuries per year among passenger car occupants at level 2 or higher on the Abbreviated Injury Scale.

The estimate of the effect of car weight is based on analyses of the number of serious injuries per 100 passenger car occupants involved in towaway crashes. In National Accident Sampling System (NASS) towaway crash data from 1981-86, a nationally representative sample of crashes, "serious" injuries are those rated level 2 or higher on the Abbreviated Injury Scale. In State accident files from Maryland (1980-87), Michigan (1982-87) and North Carolina (1980-87), "serious" injuries include those rated fatal or incapacitating (A) by police. Injury rates as a function of car weight are as follows:

Serious Injury Rate per 100 Drivers
in Single Vehicle Nonrollover Towaway Crashes

	Car Weight (Pounds)					
	Up to 1949	1950-2449	2450-2949	2950-3449	3450-3949	3950 and up
NASS	10.16	12.42	11.40	9.39	9.70	7.40
Maryland	14.75	14.80	14.26	13.15	12.03	10.66
Michigan	9.78	10.05	9.01	8.39	7.62	8.08
North Carolina	13.12	12.30	11.34	11.00	11.08	10.47

These data are not adjusted for differences in crash speed, victim age, or impact location. However, a separate analysis was performed on the NASS data controlling for the effect of those factors, resulting in just about the same relationship between car size and injury risk.

The rates in the preceding table show a trend of decreasing injury risk as car size increases. A line was fit through the injury rates, resulting in a model estimating that the national:

Serious Injury Rate = 14.1 - 0.00134 * Car Weight in Pounds.

The model was used with the average annual fleet weight to estimate the effect of reductions in fleet weight. When the average car weighs 3,700 pounds, the model estimates that there would be 42,900 serious injuries per year. When the average car weighs 2,700 pounds, the model estimates that there would be 49,200 serious injuries per year. Thus, a 1000 pound reduction in car weight is associated with a 15 percent increase in the number of serious injuries received in single-vehicle nonrollover crashes (i.e., 6,300 additional injuries per year).

This model and these results do not account for differences in the number of crash involvements by car weight. State data consistently show that lighter cars have more single-vehicle nonrollover crashes per registered car than do heavier cars. To the extent that this greater crash involvement is caused by the car itself, the model underestimates that effect of car downsizing. But if differences in crash involvement are largely the effect of vehicle use differences (different drivers, amounts of travel, and riskiness of travel), then increases in injuries given a crash are a useful measure of the probable increase in injuries associated with the shift to lighter cars.

Analysis of Fatalities in Single-Vehicle Nonrollovers

Fatal single-vehicle nonrollover crashes typically involve a car running, sliding or spinning off the road and striking a fixed object such as a tree, utility pole or bridge, with the impact on the front or side of the car. In 1989 these fatal crashes accounted for 7,108 occupant fatalities.

Data from the State of Texas for calendar years 1984 through 1987 were used to estimate the effect of car weight on the likelihood of fatal injury in those crashes. The dependent variable was dichotomous, indicating whether or not the driver received a fatal injury in the crash. Using this type of dependent variable, the analytical method of choice was logistic regression. This method was selected because it presents the probability of an outcome in terms of several independent variables, allowing the construction of a model that adjusts for covariate factors, while measuring the effect of weight.

The following variables were initially used in developing a model of injury likelihood: vehicle weight, driver age, driver sex, a variable representing the level of damage to the vehicle, a variable representing two-door vehicles (yes/no), a variable representing posted speed limit of 55 mph or greater (yes/no), and a variable for frontal vehicle damage (yes/no). Only the first four variables were statistically significant as a result of the model estimation.

The model results indicated that the likelihood of fatal injury increases as vehicle weight decreases. Thus, drivers of lighter cars are at significantly greater risk of fatal injury than are drivers of heavier cars in single-vehicle nonrollover crashes.

The model estimates that a fleet of cars with an average weight of 2,700 pounds involved in these crashes will have 9.8 percent more fatalities than will a fleet averaging 3,700 pounds, all other things being equal. If the fleet had averaged 3,700 pounds in calendar year 1989 when there were 7,108 fatalities in these crashes, it is estimated that there would have been only 6,475 fatalities. Thus, car weight reduction is associated with an increase of 633 fatalities per year in single-vehicle nonrollover crashes.

This estimate takes into account only the crashworthiness effect of car weight reductions. That is, the current analysis was conducted under the assumption of "given a crash, what is the likelihood of driver injury". If lighter, smaller cars have an additional disadvantage of being more prone to loss of control and running off the road compared to heavier, larger cars, this effect is not included in the estimate, as this would be expected to result in more crashes as well as more fatal injuries in these crashes.

Analysis of Two-Car Crashes

Crashes involving two passenger cars include head-on, front-to-rear and left- and right-side collisions, resulting in approximately 129,000 serious injuries (including 5,188 fatalities). "Serious" injuries, in these analyses, are those rated fatal or incapacitating (A-injury) by police.

A unique factor in the analysis of two-car collisions is that the weight of both cars must be considered. For example, making car number 1 lighter increases the serious injury risk for occupants of car number 1, but reduces the risk for occupants of car number 2. While it is well known that a lighter car is at a disadvantage when colliding with a heavier car, many people are uncertain as to whether a collision of two light cars is necessarily worse than a collision between two heavy cars. The purpose of the analysis is to discover what happens when all cars on the road get lighter.

Data from the State of Texas for calendar years 1984 through 1987 were used in a logistic regression model to estimate the effect of car weight on the likelihood of serious injury in these crashes. The following variables were statistically significant as a result of estimating the model of injury likelihood: the driver's vehicle weight, the ratio of the two vehicles' weights, driver age, driver sex, urban/rural accident location, a variable representing a collision with the passenger compartment and variables for the various impact locations (head-on, left-side, right-side, rear-end, and frontal damage).

The model results indicated that the likelihood of serious injury increases significantly as the weights of both cars decrease by equal proportions. In other words, a collision between two lighter cars is more likely to result in serious injury than a collision between two heavier cars. In addition, the significance of the variable for the ratio of the two vehicle weights indicated that in a two-car crash, the occupants of the lighter car are at significantly greater risk of serious injury than are the occupants of the heavier car. (If the assumption that all car weights decreased by equal proportions is replaced by another scenario of downsizing, the quantitative estimate of the effect of weight reduction would likely be somewhat different, although its direction would be the same.)

The model estimates that a fleet of cars with an average weight of 2,700 pounds involved in these crashes will have 14.3 percent more serious injuries than will a fleet averaging 3,700 pounds, all other things being equal. If the fleet had averaged 3,700 pounds in calendar year 1989 when there were an estimated 129,000 serious injuries in these crashes, it is estimated that there would have been only 113,000 serious injuries. Thus, car weight reduction is associated with an increase of approximately 16,000 serious injuries per year in two-car crashes.

Data from the State of Maryland for calendar years 1984 through 1988 were used to conduct another analysis of two-car crashes, investigating the changes in the likelihood of serious injury. The same types of variables used in the Texas analysis were used for the State of Maryland. The considerably smaller Maryland sample produced results that also indicated a greater risk in collisions between two lighter cars than in collisions between two heavier cars; however, the difference was not statistically significant. From these results it was estimated that occupants of a fleet of cars with average vehicle weight of 2,700 pounds would suffer 4.3 percent more serious injuries compared to occupants of a fleet of cars averaging 3,700 pounds. This equates to an additional 5,300 serious injuries per year.

The Texas and Maryland files contained insufficient numbers of fatal accident cases for statistically meaningful analyses of the effect of car weight on fatalities in two-car crashes.

Analysis of Serious Injuries in Crashes between a Car and a Large Truck

Collisions between passenger cars and large trucks (including all trucks weighing 10,000 pounds or more, plus tractor-trailers) resulted in 17,900 serious injuries to the passenger car occupants in 1989. "Serious" injuries, in these analyses, are those rated fatal or incapacitating (A-injury) by police. Due to the large mass disparity of the two vehicles, the occupants of the large trucks are rarely injured and it is safe to say that changes in the weights of the cars will not substantially affect injury risk for the occupants of the trucks. The purpose of the analysis is to find out if a reduction of car weight will increase injury risk for the car occupants.

Data from the State of Texas for calendar years 1984 through 1987 were used in a logistic regression model to estimate the effect of car weight on the likelihood of serious injury in these crashes. The following variables were statistically significant as a result of estimating the model of injury likelihood: the driver's vehicle weight, driver age and whether there was a head-on collision.

The model results indicated that the likelihood of serious injury to the driver of the car increases significantly as the weight of the car decreases.

The model estimates that a fleet of cars with an average weight of 2,700 pounds involved in these crashes will have 11.0 percent more serious injuries than will a fleet averaging 3,700 pounds, all other things being equal. If the fleet had averaged 3,700 pounds in calendar year 1989 when there were an estimated 17,900 serious injuries in these crashes, it is estimated that there would have been only 16,100 serious injuries. Thus, car weight reduction is associated with an increase of approximately 1,800 serious injuries per year in two-car crashes.

Analysis of the Effect of Car Size on Crash Test Results

NHTSA studies of accident data conclude that occupants of lighter cars are at greater risk of injury and death than occupants of heavy cars, even after controlling for crash severity. The conclusion is supported by an analysis of the structural characteristics of the passenger car fleet, based on the agency's crash test program.

In 1979, NHTSA established the New Car Assessment Program (NCAP) to provide information to consumers on the relative crash protection offered to occupants in a 35 mph barrier crash. The test can be likened to two similar vehicles striking each other head-on, each traveling 35 mph (70 mph closing speed) or the vehicle striking an immovable object, such as a bridge abutment, at 35 mph. Since 1979, more than 300 NCAP tests have been conducted. In addition, since 1986, 70 crash tests have been conducted at 30 mph to evaluate compliance with Federal Motor Vehicle Safety Standard 208 (automatic occupant protection).

The data from the crash tests were used to examine the differences between the potential safety performance of lighter and heavier passenger cars in frontal crashes. The NCAP and Standard 208 data are divided into two groups: a lighter vehicle group of cars with test weights below 3000 pounds (corresponding approximately to curb weights below 2500 pounds) and a heavier group with test weights above 3200 pounds. Data for vehicles between 3000 and 3200 pounds were not examined to eliminate "boundary" effects. The NCAP data base consisted of 120 lighter and 127 heavier cars and the Standard 208 data base, 20 lighter and 38 heavier cars. For each group, potential risk is assessed for restrained and unrestrained front seat occupants in the two crash severities.

Computer analyses of the structural characteristics show that the lighter cars expose the unrestrained occupants to more danger than heavier cars. This occurs because, as the structure collapses during the crash, forces are imposed on the small car occupant more quickly and in a more concentrated manner than for the occupant in a large car. These forces result in the unrestrained occupants of lighter cars contacting interior surfaces (steering assemblies, windshields, etc.) at velocities up to 6 mph higher than those in the heavier cars.

Analyses of the force measurements on the restrained anthropomorphic dummies in the NCAP tests show that lighter cars also expose restrained occupants to more danger than heavier cars. Relationships have been calibrated between force measurements on the dummies and actual probabilities of injury for human occupants in similar crash situations. Based on these relationships, the probability of life-threatening head injuries is approximately 14 percent for the restrained occupants of heavier cars in a 35 mph barrier collision (NCAP type crash). The probability of such injuries is approximately 21 percent for the restrained occupants of lighter cars in identical 35 mph barrier collisions. In other words, the restrained occupants of lighter cars have a 50 percent higher injury risk in a similar barrier crash situation.